NASA OCCUPANT PROTECTION STANDARDS DEVELOPMENT

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Current National Aeronautics and Space Administration (NASA) occupant protection standards and requirements are based on extrapolations of biodynamic models, which were based on human tests performed under pre-Space Shuttle human flight programs where the occupants were in different suit and seat configurations than is expected for the Multi Purpose Crew Vehicle (MPCV) and Commercial Crew programs. As a result, there is limited statistical validity to the occupant protection standards. Furthermore, the current standards and requirements have not been validated in relevant spaceflight suit, seat configurations or loading conditions.

The objectives of this study were to develop new standards and requirements for occupant protection and rigorously validate these new standards with sub-injurious human testing. To accomplish these objectives we began by determining which critical injuries NASA would like to protect for. We then defined the anthropomorphic test device (ATD) and the associated injury metrics of interest. Finally, we conducted a literature review of available data for the Test Device for Human Occupant Restraint – New Technology (THOR-NT) ATD to determine injury assessment reference values (IARV) to serve as a baseline for further development. To better understand NASA's environment, we propose conducting sub-injurious human testing in spaceflight seat and suit configurations with spaceflight dynamic loads, with a sufficiently high number of subjects to validate no injury during nominal landing loads. In addition to validate nominal loads, the THOR-NT ATD will be tested in the same conditions as the human volunteers, allowing correlation between human and ATD responses covering the Orion nominal landing environment and commercial vehicle expected nominal environments. All testing will be conducted without the suit and with the suit to ascertain the contribution of the suit to human and ATD responses. In addition to the testing campaign proposed, additional data analysis is proposed to mine existing human injury and response data from other sources, including military volunteer testing, automotive Crash Injury Research Engineering Network (CIREN), and IndyCar impact and injury data. These data sources can allow a better extrapolation of the ATD responses to off-nominal conditions above the nominal range that can safely be tested. These elements will be used to develop injury risk functions for each of the injury metrics measured from the ATD. These risk functions would serve as the basis for the NASA standards. Finally, we propose defining standard test methodology for evaluating future spacecraft designs against the IARVs, including developing a star-rating system to allow crew safety comparisons between vehicles.